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Abstract

Micro-level productivity measurement suffers from unobserved markup variation when the quantities of input and outputs are proxied by nominal variables. Early literature often adjusts the revenue and input expenditure variables by aggregate price deflators, but the idiosyncratic price effects still remain in the productivity index. This is particularly important if the unobserved markup variation has a non-random distribution. For instance, recent empirical findings (Eslava et al., 2004; Foster et al. 2008) show that entrants face asymmetric demand shocks that restrict their pricing behavior and profitability in the start-up phase. In this paper, we derive a production function estimation methodology based on a control function approach that retrieves the markup estimates separately for the entrants and incumbents, and provides a productivity index that is adjusted according to the markup variation of the entrants. Our methodology does not require observing the prices at the micro-level, and the implications can be tested for widely available firm or plant level datasets. We test our predictions using plant-level data of the manufacturing industries in Japan and Korea. Our findings show that entrants set on average lower markups than incumbents in both countries. Moreover, the contributions of entrants to aggregate productivity growth are higher with the adjusted productivity measure than those based on the standard labor and total factor productivity indices.

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1 Introduction

The producer level entry is widely thought to be among the main driving forces of productivity growth and development. Entrants can start up with new production technologies and up-to-date managerial and organizational structures which may be costly to adopt by the existing producers that are already operating with the vintage capital or other obsolete and non-variable production factors. More importantly, the entry of new production methods further promotes potential entrants and incumbents to catch up with the technological frontier and accelerates the growth through technological diffusion.

However, the empirical research on firm dynamics often conclude that the overall productivity gains from the entry of producers are realized rather lately that can take 5 to 10 years after the time of entry. One reason for this is that existing firms or potential entrants need some time to observe and adopt the new technologies which may be further postponed due to the patent and copyright ownership regulations that legally hinder the immediate adaptation of new innovations. Moreover, if we focus only on the new production units' own productivity performances, which constitutes the main focus of this paper, then it is generally believed that the newly created production units need a certain period of time to exploit their technological advantage and contribute to the aggregate productivity growth[1]. This is mainly attributed to the inevitable process of learning the market conditions which requires particular time for entrants to reach the size and the profitability scale advantages of incumbents. Additionally, traditional productivity indices in the form of labor or total factor productivity usually indicate that in their first years, the entrants' productivity performances are poor relative to the industry average.

However, if productivity measures the efficiency in the production, it may not be directly correlated with the profitability or size, since it ideally does not reflect the demand side effects or any other factors that may influence the input or output prices but not the quantity based input-output ratios. In the recent paper series, Eslava et al. (2004) and Foster et al. (2008) particularly focus on the difference between the quantity and the nominal sales based productivity measures. Their findings reflect that the demand side factors faced in the product market basically affect the profitability conditions of firms, but the quantity based input-output ratios are rather irrespective of the externally sourced firm specific price variations. Therefore, while the producers make the entry and exit decision according to their profitability status, their actual (quantity based) productivity may not play a major role in the survival decisions, if the idiosyncratic demand shocks are highly effective in the determination of firm profits. While the weak link between profitability and productivity partially explains the existence of high degrees of heterogeneity in the productivity levels

[1] Foster et al. (2001) and Bartelsman et al. (2005) find empirical support for the fact that entrants require around 5 years to exploit their productivity advantage. Olley and Pakes (1996) conclude that new entrants in the U.S. telecommunication industry have rather slow productivity performances in the start-up phase, but the ones who survive experience on average higher productivity growth than the incumbents.

of the incumbent establishments, the traditional measures of productivity for which output is often proxied by the nominal sales, that may or may not be adjusted by aggregate price deflators, would still involve these firm specific price effects. This is particularly important for the analysis of entrants' productivity dynamics, since the newly created production units often face asymmetric demand shocks in the start-up phase.

Recent empirical research on firm or plant level productivity dynamics highlights the importance of taking account of the demand side effects involved in the price-cost markups. However, while there are various studies that control for markup variations across industries, there is not much said about the within industry variation, in particular the difference of the markups between entrants and incumbents in the absence of a disaggregated price index. In this paper, we offer a production function estimation approach to control for the asymmetric price effects faced by the entrants when the firm level prices are unobserved. Our econometric algorithm relies on Hall's (1987, 1988) methodology that provides an estimate for the industry-markup jointly with a productivity index by introducing the demand side into the structural model of the production process.

Besides considering an extension of the original method to take account of the markup variation of entrants, we further deviate from the Hall's approach in two additional aspects. Firstly, the markups which are different from one not only bias the estimates of the productivity, but also the factor elasticities in the production function. This is of particular importance for the analysis of the entrants' productivity growth contribution, because if entrants charge on average lower markups than incumbents, then we would expect the traditional production function estimation methods to provide upward biased estimates for the entrants' factor elasticities and the degree of total returns to scale. Therefore, our approach further abolishes the standard assumption of constant factor elasticity for all producers in the industry, and retrieves the productivity index by also taking into account the degree of returns to scale variation of entrants.

Lastly, in addition to the well known problem of the endogeneity of input usage to production, price-cost markups and productivity are possibly correlated which requires particular attention in their joint estimation. We handle this by introducing a control function approach relying on Levinsohn and Petrin (2003). However, our estimation method also differs from the traditional methods of production function estimation with control function (Olley and Pakes, 1996; Levinsohn and Petrin, 2003), because we abolish the questionable identification assumption for the coefficient of labor input in the first stage of the estimation routine. The last section of the study is devoted to the comparison of the productivity growth contributions of entrants measured by the traditional productivity indices and the productivity obtained from the proposed approach through a decomposition methodology based on Foster et al. (2001). This further provides the opportunity to consistently evaluate the growth performances for an arbitrary time interval and the results to be easily comparable with the findings of the previous studies.

2 The Role of Entry in Productivity Growth

In the theoretical models of firm dynamics where productivity is the sole exogenous source of firm level heterogeneity, there is a perfect correlation between the market share or firm size and the productivity. Thus, one can rely on any of these firm level indicators to attain the market entry and exit thresholds or the survival probabilities for which productivity is often a good candidate, since its measurement is not an issue in a theoretical setting. However, in the real world, managers make their decisions according to the production unit's profitability, which may not be highly correlated with the idiosyncratic productivity as long as the production unit faces other firm specific shocks in the product or input markets. Thus, any other exogenous source of firm level heterogeneity may break down the theoretical relationship between the productivity and profitability that can also partially explain the high degrees of heterogeneity in the productivity distribution observed in many of today's industry or economies.

The difference between productivity and profitability can be particularly large for the entrant firms who are in the learning phase of the market conditions. Newly created production units may asymmetrically suffer from various imperfections such as the frictions in the product and input markets, sunk commitments and costs of advertisement to attract new customers that would lead their size and profits to be lower than the incumbents (Geroski, 1995; Sutton, 1997; Caves 1998). This may also induce high mortality rates for the group of entrants, but the new establishments that could survive after the start-up phase often experience higher growth rates than those of the existing production units (Evans, 1987; Dunne et al. 1989; Audretsch and Mahmood, 1995). However, the technical efficiency in the production process, which is ideally observed through not the nominal but the quantity of output to input ratios, would not be so sensitive to abovementioned asymmetric effects even for the production units that are at the start-up phase, but already combines the production factors with the predetermined production technology.

The weakness of the link between productivity and profitability may not only affect the dispersion in the productivity distribution, but also the measurement of the productivity index. If firm level productivity is measured by the nominal input expenditures and sales rather than actual quantities, then the correlation between the productivity index and the actual productivity would be also weak. In the novel paper series, Eslava et al. (2004) and Foster et al. (2008) analyze Colombian firm level dataset where the prices and quantities of the firms' outputs are separately observed. The analysis is developed over within-sector comparisons of two different productivity indices for which the revenues and the actual quantities are used to proxy the firms' outputs. Their findings show that when the productivity is based on the revenues, the productivity index is highly influenced by the demand side factors, which leads the inferences derived from revenue based productivity measures to be rather distorted in comparison to the actual dynamics observed in the quantity based productivity. In particular, the entrants' productivity levels are observed to be on average lower than the incumbents when the index is based on revenues, while the difference disappears in the quantity based index. Foster et al. (2008) attribute this to the fact that entrants charge lower prices in the first years of their life time. Therefore, the revenue based productivity index involves idiosyncratic price effects, which are highly sensitive to any type of firm specific shocks generated outside of the technical production process and may possibly pull down the index value for the entrants, while their actual (quantity based) productivity levels are much higher.

Even though the empirical support on the entrants' high productivity performance is quite limited, economists often believe that older production units are rather slow in catching up with the technological frontier, but newly created plants are more flexible and innovative, so that they constitute the dynamic part of the industry and foster the productivity growth in the long-run. The theoretical literature that can be grouped as the vintage capital models bring an explanation for the static feature of the mature firms, so that older incumbents operate with partially or fully vintage production factors and technology, which they set it up during the starting period and exhibit rather smooth or declining productivity performances throughout the life time unless hit by random shocks (e.g. Jovanovic, 1998; Doms and Dunne, 1998; Cooper et al., 1999). It is indeed difficult for a mature production unit to significantly reform the production process with the existing input combination, because the production factors are to some degree specific to the current production technology. As is extensively discussed in Caballero and Hammour (1998), the production factors often exhibit high degrees of specificity for the existing match and the production technology, which creates additional costs in the liquidation phase of the separated factors of production. "*More precisely, a factor is specific with respect to a given production arrangement -its current production relationship with other factors using a given technology- when its value would diminish if used outside this arrangement*" (Caballero, 2007). On the other hand, entrant firms are often equipped by latest technology that drives the incumbents' performance to be relatively poor in time. Unless there are significant barriers on entry and exit, this process is expected to lead the creative destruction where more productive entrants pushes the inefficient production units out of the market and sustain the productivity growth. Therefore, if the existing units in an industry are not flexible enough to catch up with the up-to-date technology, then the entry of producers would constitute a vital source of productivity growth.

3 Unobserved Prices, Markups and the Productivity Measurement

The empirical literature of productivity analysis relies on micro-level productivity indices such as the labor and total factor productivity that basically measure the efficiency in the use of inputs to produce the outputs. However, an important problem faced in the measurement of productivity is that, the actual quantity of output is generally unobserved by the researcher. Thus, the output is often proxied by nominal sales that involve not only supply side factors but also demand side influences which do not play a role in the creation of the technical efficiency of the production process.

Observing the nominal sales rather than actual quantities and prices is a common problem in the productivity analysis. Particularly, traditional methods of productivity accounting often ignores the variation in the plant or firm specific price-cost markups and assumes perfect competition that may cause the productivity measurement to be substantially distorted by the idiosyncratic demand side factors.

The literature that analyzes the problems due to imperfect information on output prices has a long history. However, the implications of lacking the micro-level prices in the productivity analysis have rather recently been attracted much attention. In his inspiring work, Hall (1987, 1988) developed an approach to estimate the markups relying on production functions where the markups enter in the structural model within the factor elasticities. While Hall's original study mainly considers industry-level productivity dynamics and concentrates on separating the markups from the degree of returns to scale, the approach is widely used in the productivity estimation with the aim of accounting for the imperfect competition (e.g. Griliches and Mariasse, 1995; Dobbelaere, 2004; Crepon et al., 2010; De Loecker and Warzynski, 2010). Griliches and Klette (1996) address the problems in the estimation of the degree of the returns from production when the output prices are not observed at the plant level and introduce the demand side into the structural model of production function in order to isolate the demand side effects involved in the factor elasticities. Katayama et al. (2003) shows that revenue based output and expenditure based inputs can lead the productivity to be mismeasured and its implications to be misleading. Levinsohn and Melitz (2004) further focused on the measurement of productivity in the presence of price-cost markups that are not equal to one. Their approach relies on a set of structural models where the supply side is represented by firms producing differentiated products in an industry of monopolistic competition, and the demand structure relies on CES type preferences. Their estimation methodology uses an aggregate demand shifter to separate the markup from the firm level productivity measure, while the markups are allowed to be different than one, but still same for all firms in the industry. The structural model drawn in Griliches and Klette (1996) and Levinsohn and Melitz (2004) is applied with various extensions such as, accounting for firm level variations in factor shares (Martin, 2005) and adjusting the industry-demand shifter to consider the plants operating in multiple industries (De Loecker, 2010).

However, so far the research on productivity under imperfect competition mostly concentrates on an aggregate level markup at the industry or economy mainly due to absence of data on the prices and quantities at the plant or firm level. However, if the within industry markup variation has a non-random pattern, then the structural models of firm dynamics should also take account of this in the analysis of productivity, in particular, when analyzing the contribution of entrants to the aggregate productivity growth. We develop a methodology to test whether the markups are indeed different for entrants, while the plant level prices or quantities are unobservable. The dataset used in this paper contains sales and input expenditures at the plant level that is generally available for a large number of countries. Our approach discussed in the next section is based on structural estimation of production functions by taking into account the endogeneity of inputs through a control function specification. However, the approach deviates from the early literature, so that we start with a general discussion on estimating markups and productivity in a structural production function specification.

4 Structural Model

Our structural model relies on Hall's (1987, 1988) approach that is widely used in the recent literature of micro-level productivity dynamics. In the formulation of the production process, we start with a general type of production function with the aim of taking into account a wide range of functional forms.

$$Q_{it} = \Theta_{it} F_{it} \left(M_{it}, L_{it}, K_{it} \right) \tag{1}$$

The function $F_{it}(\cdot)$ is homogenous of degree λ_{it} in its arguments. Q_{it}, M_{it}, L_{it} and K_{it} are the plant level output, intermediate input, labor and capital respectively, and Θ_{it} is the total factor productivity of plant i at time t. Moreover, α_{it}^{J}'s are the respective factor elasticity parameters where $J \in \{M,\ L,\ K\}$. By applying the first order Taylor expansion of Q_{it} around Q_{it-1}, the production function can be written in terms of first differences.

$$\Delta Q_{it} = \Theta_{it} \left(F_M \Delta M_{it} + F_L \Delta L_{it} + F_K \Delta K_{it} \right) + F \Delta \Theta_{it} \tag{2}$$

In equation 3, $\Theta_{it} F_J$'s represent the derivatives of the production function with respect to production factors. Hall's approach takes into account the plant level variation in the factor elasticity due to the price-cost markup differences of the production units. This necessitates writing the production function in terms of markups and factor expenditure shares in total revenue, for which we further need to assume the optimality condition retrieved from the plant's maximization problem. One can drive such a condition by assuming the plants producing differentiated products, and $P_{it}\left(Q_{it}\right)$ represents the plant level inverse demand function and the price, where the demand elasticity is equal to $-1/\eta_{it}$[2]. c_{it} representing the price of the intermediate input, the FOC of plant i's static maximization problem for the intermediate input can be given as follows.

$$\frac{\partial P_{it}\left(Q_{it}\right)}{\partial M_{it}} Q_{it} + P_{it}\left(Q_{it}\right) \Theta_{it} F_M = c_{it} \tag{3}$$

By imposing the identity $\Theta_{it} F_M M_{it} = \alpha_{it}^{M} Q_{it}$ and rearranging the terms, we obtain the following condition that allows us to substitute the factor elasticity in

[2] In the main text, we utilize a general Bertrand competition model, where prices are set in a Nash equilibrium (see Roller and Sickles, 2000). However, alternative specifications, such as Cournot game in quantities under aggregate demand function, would yield a similar expression.

the production function with the variable that is the multiplication of markups and factor shares.

$$\mu_{it} s_{it}^{M} = \alpha_{it}^{M} \tag{4}$$

Thus, $\mu_{it} = (1 - 1/\eta_{it})^{-1}$ is the markup term and $s_{it}^{M} = c_{it} M_{it} / P_{it} Q_{it}$ is the intermediate input expenditure share in revenue[3]. We further assume that the condition given in equation 4 holds for other inputs of production. Therefore, together with the identity $\Delta X_{it}/X_{it} = \Delta \ln X_{it} = \Delta x_{it}$, we substitute equation 3 into 2, and a reduced form of the production function can be written as follows.

$$\Delta q_{it} = \mu_{it} \left(\frac{c_{it} M_{it}}{P_{it} Q_{it}} \Delta m_{it} + \frac{w_{it} L_{it}}{P_{it} Q_{it}} \Delta l_{it} + \frac{r_{it} K_{it}}{P_{it} Q_{it}} \Delta k_{it} \right) + \Delta \theta_{it} \tag{5}$$

In the above formulation, r_{it} and w_{it} represents the plant specific user cost of capital and the wage rate. It is worth noting that while the user cost of intermediate and labor inputs or the total expenditures on these production factors are often observable in the data, the user cost of capital is unobservable in most cases. There are various methods to calculate the user cost of capital in the accounting literature, but they often rely on strict assumptions on firm behavior, which results in a fixed user cost term that is same for all firms, or introduces additional error into the estimation procedure. In this study, we stand on the side of the fact that the user cost of capital input is actually unobservable. In order to solve this problem, we define λ_{it} to be the degree of returns to scale in production, so that the capital input elasticity can be written as $\alpha_{it}^{K} = \lambda_{it} - \alpha_{it}^{L} - \alpha_{it}^{M}$. By introducing this identity into equation 5, the production function can be represented in the following form.

$$\Delta q_{it} = \mu_{it} \left[s_{it}^{M} \left(\Delta m_{it} - \Delta k_{it} \right) + s_{it}^{L} \left(\Delta l_{it} - \Delta k_{it} \right) \right] + \lambda_{it} \Delta k_{it} + \Delta \theta_{it} \tag{6}$$

The specification of the production function in the form of equation 6 is particularly convenient, since it does not require assuming a value for the degree of total returns to scale. Moreover, the functional form abolishes widely used restrictions on the factor elasticities that are often assumed to be constant and same for all firms in the industry. However, estimating equation 6 would only provide aggregate level parameter estimates of μ and λ, but our main interest is the variation of μ for the entrant firms. Therefore, in order to calculate the entrants' markups separately, one can introduce an entrant dummy into the final equation in the following way.

$$\begin{aligned} \Delta q_{it} &= \mu \left[s_{it}^{M} \left(\Delta m_{it} - \Delta k_{it} \right) + s_{it}^{L} \left(\Delta l_{it} - \Delta k_{it} \right) \right] \\ &\quad + \tilde{\mu} \left[s_{it}^{M} \left(\Delta m_{it} - \Delta k_{it} \right) + s_{it}^{L} \left(\Delta l_{it} - \Delta k_{it} \right) \right] D_{ent,it} \\ &\quad + \lambda \Delta k_{it} + \tilde{\lambda} \Delta k_{it} D_{ent,it} + \beta_{ent} D_{ent,it} + \Delta \theta_{it} \end{aligned} \tag{7}$$

In the above equation, $D_{ent,it}$ represents the entry dummy that takes the value of 1 in the first four-years of the plant, if it is an entrant, and otherwise

[3] Since the production function is written in terms of first differences, in the estimation, we consider the average input shares that is $\bar{\alpha}_{it}^{J} = (\alpha_{it}^{J} + \alpha_{it-1}^{J})/2$.

it is 0. Therefore, the parameter $\tilde{\mu} = \mu_{ent} - \mu$ stands for the difference between the markups of the group of entrants and the other firms in the industry (in the following parts we refer the other firms as incumbents but they also include the exiter firms), where β_{ent} captures other fixed effects that varies for the entrant firms. Thus, once we identify μ and μ_{ent} separately, we can retrieve the plant specific productivity growth index by accounting for the difference between entrants' and incumbents' markups. We specify the entry dummy to cover first four years of the entrants for two reasons. Firstly, this period is often considered as the start-up phase in which the firm is expected to conduct learning-by-doing type activities and possibly cannot exploit its productivity advantage (Foster et al., 2001; Bartelsman et al., 2005). Secondly, by writing the estimating equation in terms of first differences, we already lose the regarding observations for the first year of each firm. Moreover, as we will see in the next section, our estimation methodology involves a GMM minimization routine where up to three lags of the production factors are used as instruments, for which one needs at least 4 time observations for the entrants, so that the entrants' markup difference is identifiable.

In addition to this, since in the formulation of the structural model the main emphasis is on the variation of the factor elasticities due to the markup differences of entrants and incumbents, one would expect the returns to scale parameter to also vary among these two plant groups in the same manner ($\lambda_{it} = \mu_{it}\left[s_{it}^M + s_{it}^L + s_{it}^K\right]$). However, theoretically, the variation in the degree of total returns to scale is not equal to the variation in the markup ($\tilde{\lambda} \neq \tilde{\mu}$). This is due to two separate sources of plant level heterogeneity involved in λ_{it} that comes from the markups and input expenditure shares. However, it is not possible to identify these two components separately due to the unobservable user cost of capital. For instance, assuming the markup of plant i at time t is above 1, then it is plausible to expect that total input expenditures to revenue ratio $(s_{it}^M + s_{it}^L + s_{it}^K)$ is lower than 1, that would lead λ_{it} to be lower than μ_{it}.

Lastly, the final form of the estimating equation (eq. 6) is advantageous over the specification given in equation 5, because the final form does not require the static optimization condition to hold for the capital input, so that the assumption $\mu_{it}s_{it}^K = \alpha_{it}^K$ is not used in the formulization of the equations 6 and 7. This is particularly important, if we stick to the conventional theory that capital is a dynamic input of production, so that the respective objective function of the maximization problem shall not be per-period profits. If this is the case, the variation in λ_{it} would not be solely explainable by the markups and factor shares, but the functional form of the equations 6 and 7 would be still consistent. It is worth noting that generally, the labor input is not also a perfectly variable input of production, especially if one proxies it by the number of workers employed in a plant. However, we proxy the labor input with a more flexible variable, the total hours worked in a given year, so that we believe the possible errors due to the static labor input assumption is minimized in the estimation. Appendix Table 1 and 2 comparatively displays the coefficients of variation of labor and material inputs for each 2-digit manufacturing industry in Japan and Korea respectively. The variations are not dramatically different for the material and the labor input usage.

5 Estimation Methodology

The Hall's (1987, 1988) approach attracted particular attention, especially because it provides an estimation of average markup relying on variables that can be easily found in micro-level data sets; in particular, it does not require data on firm or plant level prices and quantities. Thus, by assuming the productivity term to be the unobserved component, the approach is highly used in the literature together with various extensions. However, the estimation of the production function specification given in equation 7 has an important shortcoming, if one considers the sample error to be the unobserved productivity. This is mainly because the unobservable component is partially observable by the manager who takes this information into account when making decisions such as hiring the factors of production, which is referred as the problem of the endogeneity of inputs to production. Moreover, there is considerable support on the persistence in the plant level productivity draws, so that the high productivity plant is often highly productive in the subsequent periods, which entails accounting for the potential serial correlation in the error term. Therefore, this part of the study discusses previously applied estimation methods and offers an alternative approach consistent with the underlying structural model.

In the estimation of the production functions in the form of equation 7, OLS or instrumental variables approaches, for which the lags of input variables are used as instruments, can be problematic in various aspects. Firstly, OLS estimates would be biased, because it does not take into account the possible correlation among the production factors and productivity due to the endogeneity problem. Namely, the manager can partially observe the production unit's productivity that would affect her optimal amount of input choice in the equilibrium. More specifically, a consistent model of productivity consists of two components, that are the productivity observed by the manager (θ_{it}) but unobserved by the econometrician, and idiosyncratic productivity shock (ε_{it}) that is i.i.d. and fully unobservable. Combining this with a more realistic scenario that there is persistence in the productivity term, then it is plausible to model the plant level productivity to evolve as a Markov process. If this is the case, the standard GMM or 2SLS type estimation methods with an instrument matrix consists of the lags of inputs would be also problematic, since θ_{it} would be still correlated with the previous periods' input usages.

Furthermore, our specification of production function contains a plant specific markup term that is possibly correlated with the unobserved productivity component. Various empirical studies such as Nickell (1996) and Aghion and Howitt (2005, 2006), provide support on the correlation between productivity and competition where the level of competition is proxied by price-cost markup based indices. In particular, Foster et al. (2008) analyze the firm dynamics in Colombian industries with separate data on the firm level price and quantities, and conclude that the price effects involved in the markup term is significantly correlated with productivity. Therefore, besides the correlation between the factors of production and the productivity term, one needs to take account of the correlation between markups and productivity that is even more difficult to control for, if it is not impossible, with the standard estimation methods based on the lagged inputs as the instrumental variables. A control function approach, that is discussed in the following parts, where the unobserved productivity component is proxied by a variable that can immediately react to the changes in productivity would take into account the correlations among inputs, markups and productivity.

The discussion developed in this section relies on two widely used control function approaches of production function estimations that are Olley and Pakes (OP) (1996) and Levinsohn and Petrin (LP) (2003). A general formulation of the estimation methodology requires a proxy variable (x_{it}) that is expected to be highly correlated with the unobserved productivity (θ_{it}). Therefore, one can define x_{it} as a function of θ_{it} and the state variable capital $x_{it} = X_{it}(\theta_{it},\ k_{it})$. Assuming $X_{it}(\cdot)$ is a monotonous function of the productivity term, then one can invert it to obtain the function, $\theta_{it} = X_{it}^{-1}(x_{it},\ k_{it})$, that stands for the unobserved productivity in the estimation. While OP and LP use investments and intermediate inputs as the proxy for the unobserved component respectively, both approaches basically assume that the proxy variable is strictly monotone in productivity. However, in the presence of incomplete competition, a firm experiencing high productivity growth may set a higher price rather than increasing its input usage to produce more amount of output. Thus, when the intensity of competition is very low, the relationship between the proxy variable and productivity may be negative which breaks down the invertibility condition. Therefore, we essentially need the assumption that firms do not set disproportionate markups as a response to the changes in the productivity. However, one should keep in mind that this form of control function approach may not be suitable when the subject industry exhibits very low level of competition with low number of producers.

The main difference between OP and LP methods comes from the selection of the proxy variable. LP criticizes the use of investments as a proxy since investments is a control on a state variable capital, and a state variable is by definition costly to adjust. In other words, investments are rather slow in responding productivity shocks, since it requires detailed analysis of market conditions, financial constraints and project feasibility. Moreover, it is often the case that firms do not invest in some periods that can breakdown the theoretical relationship between the proxy variable and the unobserved component. Besides the abovementioned shortcomings of using investments as the proxy, we do not have observations on the plant level investments, which makes the OP method inapplicable in our case. On the other hand, LP method offers the usage of the materials as the proxy for unobserved productivity, since the amount of materials used in the production can be adjusted relatively quickly to the changing conditions, and most of the production units need positive amounts of materials in order to produce their product that solves the zero value problem in the proxy vector. Therefore, our approach mainly relies on LP method, but we considerably deviate from the original procedure for reasons that are discussed in the following parts.

In the estimation of production functions, LP approach is rather convenient to apply, since there are already written programing codes for which one only needs the variables to be set in a proper way. However, our reduced form estimating equation (eq. 7) requires not the estimates of the factor elasticities but the respective markups that necessitates revising the estimation strategy in the following way.

Firstly, we use the materials input as the proxy variable where it enters directly into the control function in the form of third-degree polynomial. However, in equation (7), the materials input is multiplied by its expenditure share in revenue $\left(s_{it}^{M} m_{it}\right)$ that requires m_{it} to be used in two different functional forms in the second step of the method. This is also the case for the labor input, but we introduce the capital in the linear form as in the original LP method, where its coefficient represents total returns in our specification.

Secondly, LP method has a critical timing assumption on the choice of the optimal amount of labor used in the production, which allows the coefficient of labor to be identified in the first stage. More specifically, LP assumes that the manager cannot observe today's productivity before the labor is hired, while this aspect of the LP algorithm attracts much criticism due to the inconsistency in the identification (e.g. Ackerberg et al., 2006; Wooldridge, 2009).

In this study, we deviate from the original assumption and introduce l_{it} as a state variable into the control function $(\phi_{it}(\cdot))$ together with the other state variable capital and the proxy variable the intermediate input. In order to sustain the notational simplicity, our formulation below is absent from the dummy variables and the terms that capture the entrants variation, so that the production function in terms of first differences takes the following form.

$$\begin{aligned} \Delta q_{it} &= \mu\left[s_{it}^{M}\left(\Delta m_{it}-\Delta k_{it}\right)+s_{it}^{L}\left(\Delta l_{it}-\Delta k_{it}\right)\right] \\ &\quad +\phi_{it}\left(m_{it}, l_{it}, k_{it}\right)-\phi_{it-1}\left(m_{it-1}, l_{it-1}, k_{it-1}\right)+\varepsilon_{it} \end{aligned} \tag{8}$$

In the above equation, the control function, $\phi_{it}(\cdot)-\phi_{it-1}(\cdot)$, represents the productivity growth term $(\Delta\theta_{it})$ that is observed by the manager and proxied by the intermediate inputs, and ε_{it} is the productivity shock that is fully unobservable and i.i.d. over time.

The first stage of the estimation method consists of a non-parametric function, $g(\cdot)$, that jointly captures the regarding input variables and unobserved productivity, and it is approximated by a third order polynomial in its arguments.

$$\Delta q_{it}=g_{it}\left(m_{it}, l_{it}, k_{it}\right)-g_{it-1}\left(m_{it-1}, l_{it-1}, k_{it-1}\right)+\varepsilon_{it} \tag{9}$$

Therefore, the first stage of the estimation routine controls for the unobserved productivity by utilizing the production factors as the state and proxy variables, but it does not identify any of the parameters that are subject to the analysis. However, the term representing the productivity growth can be retrieved for any given values of the parameter estimates of μ and λ in the following way.

$$\begin{aligned}\Delta\theta_{it} &= \left[g_{it}\left(m_{it}, l_{it}, k_{it}\right) - g_{it-1}\left(m_{it-1}, l_{it-1}, k_{it-1}\right)\right] \\ &\quad -\hat{\mu}^{*}\left[s_{it}^{M}\left(\Delta m_{it} - \Delta k_{it}\right) + s_{it}^{L}\left(\Delta l_{it} - \Delta k_{it}\right)\right] - \hat{\lambda}^{*}\Delta k_{it}\end{aligned} \tag{10}$$

As in LP, the second stage starts with the assumption that productivity follows an unknown first order Markov process, so that $\theta_{it} = z\left(\theta_{it-1}\right) + e_{it}$. Therefore, the productivity growth can also be written as a function of θ_{it-1}, namely, $\Delta\theta_{it} = z\left(\theta_{it-1}\right) - \theta_{it-1} + e_{it}$. Since the term $z\left(\theta_{it-1}\right) - \theta_{it-1}$ is an unknown function of the previous period's productivity draw, we further approximate it with a non-parametric function $\tilde{z}\left(\cdot\right)$ that is in the form of third order polynomial in its arguments, and rewrite the unknown first-order Markov process for given $\hat{\mu}$ and $\hat{\lambda}$ as follows.

$$\Delta\theta_{it} = \tilde{z}\left(m_{it-1}, l_{it-1}, k_{it-1}\right) + e_{it} \tag{11}$$

Accordingly, for given $\hat{\mu}$ and $\hat{\lambda}$, one can retrieve the fitted values of the above regression to be used as an estimate for the expectation of productivity growth conditional on previous period's productivity realization $\widehat{E\left(\Delta\theta_{it} \mid \theta_{it-1}\right)}$. Therefore, the second stage of the estimation routine takes the following form.

$$\begin{aligned}\Delta q_{it} &= \mu\left[s_{it}^{M}\left(\Delta m_{it} - \Delta k_{it}\right) + s_{it}^{L}\left(\Delta l_{it} - \Delta k_{it}\right)\right] + \lambda\Delta k_{it} \\ &\quad +\tilde{z}\left(m_{it-1}, l_{it-1}, k_{it-1}\right) + \varepsilon_{it} + e_{it}\end{aligned} \tag{12}$$

Joint minimization of the error terms ε_{it} and e_{it} would provide the estimates of the subject parameters, μ and λ, including the terms representing the entrants' markup and returns to scale variation that are $\tilde{\mu}$ and $\tilde{\lambda}$. Thus, the solution for the following minimization problem with H number of instruments $Z_{it,j}$, $j = 1$ to H, would identify the regarding parameters.

$$\min_{\left\{\mu, \tilde{\mu}, \lambda, \tilde{\lambda}\right\}} \sum_{h}^{H}\left[\frac{1}{T}\frac{1}{N}\sum_{t}^{T}\sum_{i}^{N}\left[\left(\varepsilon_{it} + e_{it}\right) Z_{it,h}\right]\right]^{2} \tag{13}$$

The instrument matrix consists of the first lag of the capital input that is assumed to be determined by the investments in $t-2$, and the second lags of capital, materials and labor inputs. Moreover, the third lags of the capital and the labor inputs are used as instruments that further provide the over identifying restrictions ($Z_{it} = \{k_{it-1}, m_{it-2}, l_{it-2}, k_{it-2}, k_{it-3}, l_{it-3}\}$). The objective function is minimized by using MATLAB's *lsqnonlin* command and the standard errors are calculated by block bootstrap replications. Since our dataset includes time dimension and productivity is assumed to be time dependent, we utilize block bootstrapping by resampling the dataset over randomly drawn plants, but using the entire times series observations of that plant. A crucial restriction on the bootstrapped samples is that we do not allow the sample to include very high or low entry rates. Namely, if the random sample does not include any entrants, then the entrants' markup variable turns out to be a zero vector that drops out in the estimation. Similarly, in case the sample covers only the entrants, the difference between the markups of the entrants and the industry average vanishes that leads one of the respective variables to be eliminated in the estimation routine. Therefore, when the random sample approaches these two extreme cases, the estimation results are not reliable. We handled this shortcoming by re-checking the created random samples, so that only the ones that approximately represent the entry rate in the original sample are considered in the construction of the standard errors.

5.1 The Data Set

We use an annual micro-level dataset of the plants operating in the manufacturing sectors of Japan and Korea during the period 1985-2005 for Japan and 1986-2005 for Korea. The complete data is publicly available in the website of "Japan Centre of Economic Research", but our sample covers a subset of the dataset that is prepared by and discussed in Fukao et. al (2009). Accordingly, the output is reported as the total sales of the plant deflated by the 2-digit industry level PPI. The labor input is reported as the total working hours employed in a plant in a given year, the intermediate input is represented by the expenditures on the materials deflated also by the industry level PPI and the capital is constructed by using total investment series through the perpetual inventory method.

We run the regressions for the total manufacturing sector of each country separately. However, it is worth noting that we would prefer to apply the estimation procedure individually for each 2-digit industry. However, there are 19 industries for both countries that would lead more than half of the industries to suffer from insufficient number of entrants if not the number of total observations. The basic statistics on the dataset are given in Appendix Tables 1, 2 and 3 and the construction of the other variables is also discussed in the appendix part.

6 Results

We apply the estimation methodology on the dataset of manufacturing plants in Japan and Korea separately. In the estimation, we use 2-digit industry and time dummies as well as the entry dummy that takes the value of 1 for four consecutive years starting from the entry year and otherwise it is zero. Moreover, we estimate equation (7) with the OLS and single-step fixed-effects GMM. In the GMM case, the instrument matrix consists of the same variables used in the proposed control function approach that are $Z_{GMM,it} = \{k_{it-1}, m_{it-2}, l_{it-2}, k_{it-2}, k_{it-3}, l_{it-3}\}$.

Table 1: Estimation Results of the Production Functions

		Japan			**Korea**	
Coef.	OLS	GMM-IV	C. Func.	OLS	GMM-IV	C. Func.
μ	1.149*	1.195*	1.348*	0.705*	1.056*	1.412*
	(0.003)	(0.055)	(0.190)	(0.006)	(0.109)	(0.326)
$\tilde{\mu}$	-0.069*	-0.674	-0.520*	-0.019*	0.328	-0.408*
	(0.007)	(0.850)	(0.113)	(0.008)	(0.548)	(0.151)
λ	1.039*	0.990*	1.108*	0.738*	1.159*	1.384*
	(0.003)	(0.059)	(0.261)	(0.006)	(0.081)	(0.249)
$\tilde{\lambda}$	-0.114*	0.064	-0.397*	0.063*	-0.286	-0.260*
	(0.006)	(0.548)	(0.117)	(0.010)	(0.193)	(0.111)

Standard errors are in parenthesis.

Time and industry dummies are included in the estimation.

*Significant at 5% level.

Table 1 displays the estimation results of the production function in the form of equation 7. Therefore, the estimated average markup of entrant plants is lower than the incumbents' average for Japanese manufacturing industries according to both OLS and control function approaches. This is in line with our previous arguments that the entrants face asymmetric effects possibly arisen from the demand or input supplier sides that restrict their pricing behavior and profitability, so that estimated markups are lower for the entrant plants for their first four-year in the market. Moreover, the degree of total returns to scale is also lower for the entrant plants. If one believes that the optimality condition given in equation 4 holds for the capital input, then we can define the identity $\hat{\lambda} = \hat{\mu}\left[s_{it}^{M} + s_{it}^{L} + s_{it}^{K}\right]$, so that we can retrieve an estimate for total expenditures on variable inputs to revenue ratio (profit margin) that is $1.108/1.348 = 0.822$ for incumbents and $0.711/0.828 = 0.859$ for entrants based on the control function approach estimates for Japanese manufacturing industries. However, as we noted before, our specification does not necessitate the static optimality condition for the capital input, and the degree of returns to scale parameter estimates may take a value irrespective of this markups and cost to profit ratio relationship.

Besides being significant at 1% level, OLS estimates of average incumbents' markup (μ) and the returns to scale (λ) are particularly low in comparison to the results obtained from the other approaches. This is mainly because, while the factors of production is expected to be positively correlated with the productivity, the input expenditure shares in revenue is negatively correlated, since the revenue, by definition, is a positive function of the productivity due to direct productivity effect and the indirect effect that comes from the amount of inputs used in the production. Thus, we conclude that for the incumbent plants the negative correlation of the input shares with the productivity is dominant over the positive correlation between the amount of production factors and productivity, so that the OLS provides lower estimates for the incumbents' markup and the degree of returns to scale. On the other hand, as it is discussed in the previous parts, we expect the entrants to have difficulties to exploit their productivity advantage in terms of revenues due to the demand side effects. Therefore, in the Japanese case, the positive correlation between production factors and productivity is expected to be dominant over the negative correlation of input expenditure shares that would lead the OLS estimates of the entrants' variation to be lower in absolute value than the results obtained from the control function approach.

On the other hand, the reliability of the standard GMM estimates with an instrument matrix consist of lagged inputs depends on the degree of persistence in the productivity over time. Namely, as it is concluded in Levinsohn and Petrin (2003), if productivity is significantly serially correlated, the previous periods' input usage would be still correlated with the error term where the error term contains the unobserved productivity component in the standard GMM and OLS specifications. Therefore, in the presence of questionable instruments such as the lagged input usage, the GMM estimates would be far from the estimates obtained from the control function approach. This is indeed the case according to the regarding results reported in Table 1, so that the coefficient estimates regarding the incumbents are significant and the values are close to the OLS estimates, but the entrants' variations in terms of the markup and returns to scale are insignificant.

The picture depicted on the right-hand side of Table 1 for Korea is not very different from the results obtained for Japanese manufacturing industries. Accordingly, the OLS and control function estimates of the entrants' markup variation is significantly negative. Moreover, the OLS estimates of the incumbents' markup and the degree of returns to scale are lower than the control function estimates possibly due to the endogeneity problem, while the entrants' total returns to scale variation is estimated to be positive with the OLS but negative with the control function approach. However, for Korea, we do not retrieve significant coefficient estimates for the entrants' variation from the standard GMM method with the lagged inputs as instruments. As it is discussed before, assuming the capital to be a static input of production, the profit margin ($s_{it}^M + s_{it}^L + s_{it}^K$) estimates based on the control function approach is $1.384/1.412 = 0.98$ for the incumbent and $1.124/1.004 = 1.12$ for the entrant plants in Korean manufacturing industries.

So far, we complete the first part of the analysis where we conclude the price-cost markups that involves the unobserved price effects are lower for the entrant plants and higher for the incumbents in both Japanese and Korean manufacturing industries. The next step is searching an answer for the question whether the productivity growth contribution of the entrants are over or underestimated with the standard productivity calculation techniques due to the ignored plant level markup variations. Next section approaches the question from two different perspectives that we first compare the annual productivity growth rates among alternative productivity indices. Secondly, the comparison is carried out for longer time spans with a discussion over and an application of the productivity growth decomposition methodology (Foster et al., 2001) where the entrants' contribution is decomposed from the overall growth rate in an empirically consistent manner.

6.1 Entrants' Productivity Growth

It is a straightforward result of the previous section that if we would consider a constant markup for the industry, the retrieved productivity growth rates for the entrant plants would be lower than the ones obtained by taking into account the markup variation, because the fitted values of the regression minus the productivity term would be higher in the constant markup case. However, whether the productivity growth rates of the entrant plants obtained from the proposed method are higher than those calculated by the traditional methods is the question that we try to answer in this part. While doing so, we utilize two alternative indices that are the labor productivity as a ratio of the deflated revenues to total working hours and the standard total factor productivity (TFP) estimated by Levinsohn and Petrin (2003) algorithm[4]. Therefore, we compare the productivity growth rates obtained through these traditional measures with the total factor productivity index that is retrieved from the above mentioned estimation methodology, which we call TFP-markup.

In the estimation of the standard TFP growth rates by Levinsohn and Petrin (2003) approach, we consider a Cobb-Douglas type production function. We calculate the growth rates by calculating the log differences, and the industry weighted average of the growth rates are calculated through the output shares (w_{it}) to be used in the formulation of the weights that are $\bar{w}_{it} = (w_{it} + w_{it-1})/2$. For averaging the growth rates of TFP-markup obtained from the proposed method, we also consider the two-year averaged output shares as weights, while the average labor productivity is weighted by the labor shares in the industry-total amount of labor in terms of working hours.

Besides comparing the results of these two alternative measures of TFP is our main aim, the labor productivity is of particular importance since in its calculation, we use the total working hours employed by a given plant in a given year that does not contain the plant-level input price effects. We further consider the labor share of each plant as the weight in averaging the growth rates. Once more, the productivity growth rates of the group of entrants are calculated by considering the first four years of the entrant plant.

Table 2: Annual Growth Rates (%) in the Manufacturing Sectors

	Japan			**Korea**		
	Entrant	Inc.	Industry	Entrant	Inc.	Industry
Labor Prod.	4.2	5.0	5.0	7.0	7.3	7.3
TFP	-3.3	0.2	0.1	-1.6	-0.7	-0.8
TFP-markup	2.6	0.8	0.8	-0.4	-3.1	-3.0
Output	5.1	3.4	3.4	28.9	11.0	11.2
Labor	0.2	-2.0	-1.9	12.7	1.0	1.3

Table 2 represents the annual average growth rates of labor productivity, TFP, TFP-markup, output and labor in the manufacturing sectors of Japan

[4] Levinsohn et al. (2004) provide the code *levpet* that applies the Levinsohn and Petrin (2003) algorithm in Stata.

and Korea by grouping the plants as entrants and incumbents. According to the left-hand side of the Table for Japanese industries, the entrant plants exhibit on average lower productivity growth than the incumbents according to the labor and standard TFP measures. Moreover, we calculate a yearly average of 5% labor productivity growth and 0.2% TFP growth in the overall sector, while the entrants TFP growth is negative with -3.3% and the labor productivity growth rate is slightly lower than the industry average. Conversely, the productivity growth rates measured by the proposed method (TFP-markup) are much higher for the entrants (2.7%) than those for the incumbents (0.7%) in Japanese manufacturing sector. In addition to this, we calculate the annual growth rates of the output (5.1%) and the labor (0.2%) to be significantly higher for the entrants, while the incumbents' labor input growth is negative. Assuming the total labor force growth rates are rather stable in Japan, the Table provides evidence, at some degree, on the fact that there is a significant reallocation of labor from the incumbents to possibly more productive entrant plants.

The right-hand side of Table 2 is devoted to Korean manufacturing sector and displays a similar scenario with the Japanese case. Therefore, the entrants' average productivity growth is lower than the industry average according to the labor productivity. The standard total factor productivity growth rates are negative for both the entrants and incumbents while the group of entrants having relatively poor TFP growth performance. The TFP-markup also indicates that the total factor productivity growth is negative for each plant group in Korean manufacturing industries, but the entrants have significantly higher productivity growth rates than the incumbents according to Table 2. Furthermore, we find negative average TFP growth in Korean overall manufacturing sector (-0.8% TFP growth and -3% TFP-markup growth), but the growth rates of the output and labor are positive and higher than the respective rates in Japan. Although analyzing the growth and productivity trends in Japan and Korea are not the main purpose of this paper, our findings are in line with the argument that Korea is experiencing higher output growth rates mainly due to expansionary growth in inputs but not TFP, while Japan's output growth rates seem to rely heavily on the growth in the plant level productivity.

Figure 1: Annual Productivity Growth (%) in Japanese Manufacturing Sector

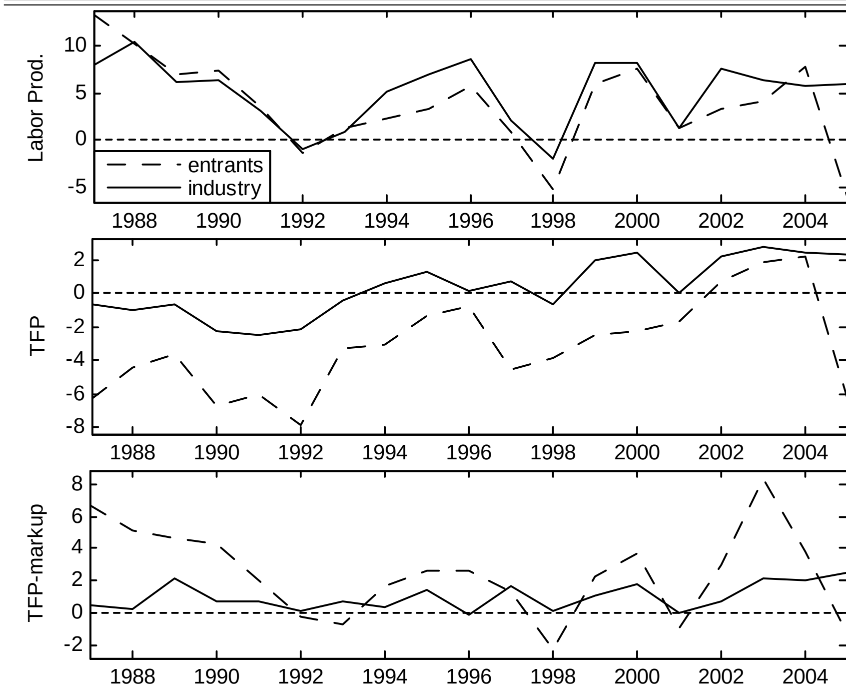

Figure 1 provides a closer look at the productivity growth performances of the manufacturing plants operating in Japan. Accordingly, the overall industry productivity growth trends with respect to TFP and TFP-markup indices are rather similar with joint downturns in the years 1993, 1996, 1998 and 2001, and booms in 1995, 1997, 2000 and 2003. Both TFP indices reflect relatively less volatile pattern in comparison to the labor productivity, and the TFP trends indicate that Japanese manufacturing sector follows an increasing productivity growth time path over the period 1987-2005. However, according to the markup adjusted index, the entrants' TFP-markup trend is rather cyclical in comparison to the industry average, while the standard measure indicates the entrants' TFP growth follows a time path that is on average much below the overall industry standard TFP pattern. In particular, the entrants' TFP-markup growth rates seem to be highly positively correlated with the entrants' labor productivity growth indicating that the input price effects also play an important role in the entrant plants' profitability and productivity dynamics in Japan, since both the labor productivity and the TFP-markup does not suffer from possible biases due to ignoring the input price variation between the entrants and incumbents.

The effect of East Asian financial crisis reveals itself with significant downturns in the three listed productivity measures during the year 1998. Financial crisis may affect the productivity performances of the plants as well as the outside market conditions, especially if the productions factors like capital are rather difficult to adjust for instant shocks. However, if the productivity index only represents the technical efficiency in the production process, but not the demand side factors such as a decrease in consumer income, then one would expect the productivity growth rates to turn back to the pre-shock levels, as soon as the imperfectly variable production factors are adjusted to the new conditions. However, if the productivity measure involves the other factors arisen from the demand or input supplier sides, it is plausible to argue that the economic downturns have rather long-lasting effects on the calculated productivity index. This is actually what we see in Figure 1, so that for the time period around 1998, the slowdown in the productivity levels are captured by both three productivity measures, while its effects are rather persistent especially in terms of the entrants' growth performances according to the standard TFP which is considered as the most sensitive index of productivity to the markup variations.

Figure 2: Annual Productivity Growth (%) in Korean Manufacturing Sector

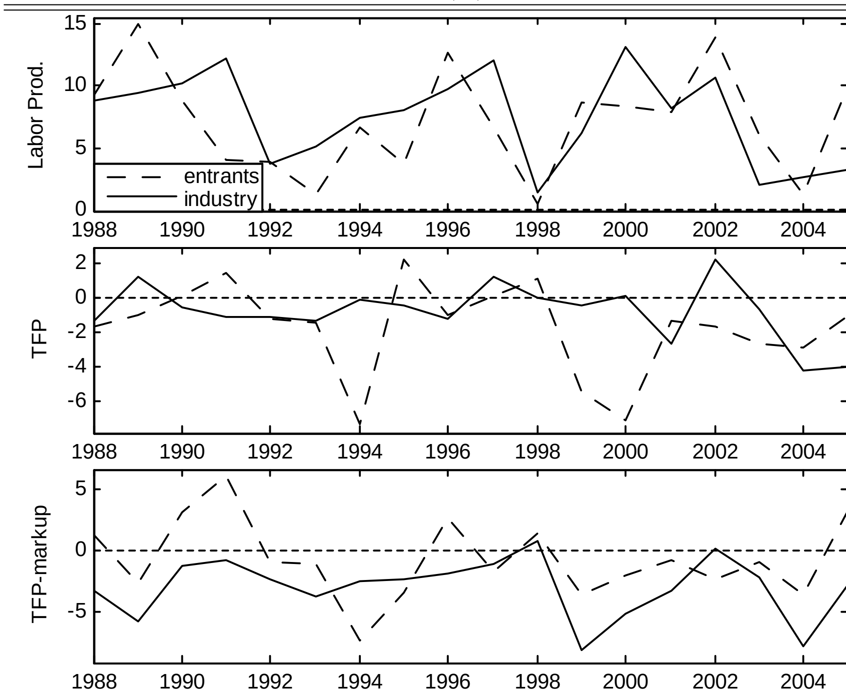

Figure 2 represents the time paths of the annual labor and total factor productivity growth rates in Korean manufacturing plants. The productivity growth rates in Korea are more volatile than the patterns observed in Japan. In particular, the labor growth rates are much higher and positive during the sample period, while the standard TFP growth average of the sector is mostly negative and the entrants' growth rates are lower in comparison to the other TFP measure. If we look at the entrants' productivity growth for the last 5 years of the sample period, we can conclude that entrant plants are experiencing higher growth rates than incumbents according to both labor productivity and TFP-markup, while these two productivity measures indicate on average lower productivity growth performance for the entrants' relative to the incumbents during the period 1994-1999 with an instant peak in 1996. On the other hand, both three indices display a rapid slow down in the year 1998 for labor productivity and 1999 for TFP-markup, and an explicit upward shift in the year 2002 where these years approximately correspond to the East Asian financial crisis and the end of the recovery period during which Korea is listed among the mostly affected countries.

The above analysis is conducted over the annual growth rates of the plants where the entrants are classified as the producers that are in the first four years of their life time. However, a more intuitive picture can be drawn by avoiding the restriction of the entry dummy and taking into account the level form of the productivity. Therefore, it might be the case that a plant group experiencing relatively high growth rates may have a productivity level that is far below the industry average, so that their contribution to industry productivity is negligibly small. Moreover, it might be also the case that our results are sensitive to the first four years of the entrants' life time, where the calculated contributions are different when we consider the dynamics in the long-run. The next section approaches the aggregation and accounting issues by taking into account these shortcomings through the productivity growth decomposition methodology developed in Foster et al. (2001).

6.2 Decomposition of the Productivity Growth

The Foster-Haltiwanger-Krizan productivity decomposition method (Foster et al., 2001), hereafter referred as FHK, provides an intuitive accounting of the entrants' productivity growth contribution; in particular, the contributions can be considered over different time intervals by taking into account the distance of each entrants' productivity level from the industry average. FHK defines the entrants as the plants that are absent in the industry at the first year of the time interval, but present in the last year. Therefore, whatever in its first four-year or not, the plant is considered as an entrant; for instance, if the time interval is 10 years, a 9-year old firm can be in the group of entrants. On the other hand, even if a plant enters into the market one year before the starting point of the time interval, the method considers it as an incumbent although the respective value of the entry dummy that is previously used in the estimation is equal to one.

The way how we apply the FHK method requires the level forms of the plant productivity indices, for which we need to make further assumptions. Our production function specification in the previous parts is in terms of first differences mainly because we do not want to restrict the estimation to a particular type of production function. However, in case one assumes a Cobb-Douglas type production function, it is possible to derive the same equation in terms of levels as in the original Hall's approach. Therefore, we retrieve the productivity index which we call TFP-markup by considering the level forms of the output and inputs with the estimated coefficients for the markups and the degrees of return to scale. Doing so provides a particular advantage that is we do not constrain the analysis with the growth rates but consider the plant or group differences also in the level forms of the productivity index.

The method necessitates the calculation of the aggregate productivity that is the average of the plant level productivity weighted by the plants' shares in total. As in the previous part, we decompose the productivity growth by using three different productivity measures that are labor, standard total factor productivity and TFP-markup indices where we consider the respective labor and output shares of the plants as the weights (w_{it}) respectively. It is important to point out that as it is empirically supported in the tradition productivity analysis, when we consider a wider time period, the productivity contribution of the entrants are expected to be positive and higher, even if their yearly contributions are negative or very small.

Accordingly, the equation 14 is the formula of FHK decomposition, where $\Delta\bar{\theta}_t = \bar{\theta}_t - \bar{\theta}_{t-k}$ represents the log differenced aggregate productivity, and θ_i's are the plant level productivity draws.

$$\begin{aligned}\Delta\bar{\theta}_t \quad = \quad & \sum_{i\in C} w_{it-k}\Delta\theta_{it} + \sum_{i\in C}\left(w_{it} - w_{it-k}\right)\left(\theta_{it-k} - \bar{\theta}_{t-k}\right) + \\ & \sum_{i\in C}\left(w_{it} - w_{it-k}\right)\Delta\theta_{it} + \sum_{i\in N} w_{it}\left(\theta_{it} - \bar{\theta}_{t-k}\right) - \sum_{i\in X} w_{it-k}\left(\theta_{it-k} - \bar{\theta}_{t-k}\right)\end{aligned} \tag{14}$$

In equation 14, C, N and X represent the set of all plants, entrants and exiters respectively. Therefore, the first term in the FHK formula is the within component that measures the firms productivity performance holding their market shares constant and equal to the initial level, so that it provides insights on the degree of firm restructuring or deterioration. The second term is the between component that measures the aggregate productivity growth contributions of the relative changes in the plant shares which can be interpreted as the productivity effects of the allocation among the establishments. The third term is the covariance of the productivity and the market share that is referred as the cross component. The cross component reflects a positive contribution to productivity growth if the expanding (shrinking) units with respect to their market share also experience positive (negative) growth in their productivity over the period whose span is represented by k in the formulation. The forth term, which is the main concern of this part of the study, is the entry component that accounts the productivity contribution of the entrants weighted by their respective shares in total. The last term on the right-hand side is the exit component that reflects whether the exiting plants during the period between t and $t-k$ have lower productivity levels than the industry average which accounts for the exiters contribution to the productivity growth.

A closer look at the entry contribution of the original FHK decomposition would reveal the fact that it calculates the productivity performance of the entrants that enter during the period of k with respect to the $t-k$'s productivity average. However, the subject industry would have experienced a positive or negative productivity growth after $t-k$ that should not be a part of the entry component. Namely, if the industry exhibits a considerable productivity growth after the initial time point $(t-k)$, a new producer that enters in time t may have lower productivity relative to the incumbents' average in time t. However, the time-t entrants' productivity may still be much higher than time $t-k$'s average that would lead the entry component to reflect high contribution to the aggregate productivity growth.

Brown and Earle (2008) (BE) realize the bias due to ignoring the possible overall positive or negative productivity growth that would over or understate the entrants' contribution, and offer an extension by further decomposing the entry component into two parts that are displayed in the below formula.

$$\sum_{i \in N} w_{it} \left(\theta_{it} - \bar{\theta}_{t-k}\right) = \sum_{i \in N} w_{it} \left(\bar{\theta}_{t} - \bar{\theta}_{t-k}\right) + \sum_{i \in N} w_{it} \left(\theta_{it} - \bar{\theta}_{t}\right) \tag{15}$$

Therefore, the BE extension separates the entry term of the FHK decomposition into two components that are the growth due to the overall industry trend (referred as agg. growth effect in the following tables) and the entrants' own productivity performance respectively where the latter component is the net contribution of the entrants (referred as the net entry component). Thus, if the industry experiences a positive overall productivity growth, the BE extension would reflect a net entry contribution that is lower than the entry component of the FHK, while it is the other way around if there is a negative industry level productivity growth.

However, if the average industry productivity growth is positive or negative, this can also be due to the entrants' own productivity contribution. Namely, the group of firms that enter into the market between t and $t-k$ would be an important driving force of the aggregate productivity growth that would still remain a bias in the BE extension. Therefore, the first term in the BE extension that accounts for the aggregate growth would capture a part of the entrants contribution that may distort the second term, the net entry component, in both ways depending on the sign of the entrants' contribution. Therefore, we further revise the BE extension in order to calculate the pure entry contribution in the below formula.

$$\sum_{i \in N} w_{it} \left(\theta_{it} - \bar{\theta}_{t-k}\right) = \sum_{i \in N} w_{it} \left(\bar{\theta}^{I}_{t} - \bar{\theta}_{t-k}\right) + \sum_{i \in N} w_{it} \left(\theta_{it} - \bar{\theta}^{I}_{t}\right) \tag{16}$$

In equation (16), $\bar{\theta}^{I}_{t}$ represents the weighted productivity average of the plants except the ones that enter into the market during the period of k. Therefore, the first term on the right-hand side of the revised BE identity represents the productivity growth performance of plants, which are not entrants, weighted by the entrants share, while the second term is the pure entry effect that measures entrants' productivity contribution with respect to all other firms in the industry.

We decompose the aggregate productivity growth in Korean and Japanese manufacturing sectors and measure the entry contribution by three different methods discussed in the previous lines. In order to do so, we set the span of decomposition to two alternative values that are $k = 5$ and 10, and decompose the productivity for every period and 2-digit manufacturing industry separately. Therefore, while averaging the components over 2-digit industries, we use the industry shares in the total manufacturing sectors as the weights, and then we take the unweighted average of the components over the time periods to reach the final statistics reported in Table 3. Lastly, the industry-level log differenced productivity ($\Delta\bar{\theta}_t$) and each respective component is multiplied by 100, so that the total growth term (Tot. Gr.) is in the percentage form.

Table 3: Decomposition of the Productivity Growth (%)

		FHK	BE Extension		Revised BE		Tot. Gr.
		Entry	Ag. Gr.	Net Ent.	Ag. Gr.	Net Ent.	$\Delta\bar{\theta}_t$*100
Japan							
5-year	LP	-0.15	0.56	-0.71	0.58	-0.73	19.20
	TFP	1.91	0.03	1.89	0.01	1.90	2.84
	TFP-m	13.82	0.80	13.02	-0.34	14.16	3.53
10-year	LP	0.78	2.49	-1.71	2.53	-1.75	41.77
	TFP	3.81	0.14	3.67	0.07	3.74	6.24
	TFP-m	12.47	0.85	11.62	-0.69	13.16	4.48
Korea							
5-year	LP	1.68	2.20	-0.52	2.12	-0.44	44.22
	TFP	0.12	-0.29	0.41	-0.24	0.36	-2.83
	TFP-m	18.47	1.84	16.63	-1.96	20.43	-4.29
10-year	LP	8.60	10.79	-2.19	10.67	-2.07	105.20
	TFP	0.69	-0.65	1.34	-0.60	1.28	-5.78
	TFP-m	20.46	-0.10	20.56	-5.86	26.32	-23.52

Table 3 displays the results of the entrants' contribution to productivity growth analysis through the FHK decomposition with three alternative entry component formulations discussed in the previous parts. As before, TFP represents the standard total factor productivity, LP stands for the labor productivity, and TFP-m is the index retrieved from the proposed method that takes into account the entrants' markup variation. The column titled as FHK represents the entry component of the original method, and the following columns are the results of the extensions in which the original entry component is separated into two as the aggregate growth and the net entry components.

The upper part of the Table demonstrates the decomposed productivity growth for Japanese manufacturing sector for 5 and 10-year spans respectively. Therefore, for the 5-year time interval, the average entry contribution to the labor productivity growth is negative with respect to both three decomposition formulations. However, the original entry component of the labor productivity decomposition turns out to be positive when we consider the averages over 10-year intervals. This is mainly due to the increase in the total growth rates for longer time spans, since when we subtract the aggregate growth effect from the FHK's entry component, the resulting net entry contribution is negative with both BE and revised BE extensions.

On the other hand our findings indicate a relatively high entry contribution to the standard TFP growth in Japanese manufacturing industries. The value of the entry component does not differ much according to the alternative decomposition formulations, but they are significantly higher when the time interval is increased to 10 years. This result is in line with the fact that with the standard TFP measure, the entrants' contribution to productivity growth is significantly positive and higher in the long term, but their overall productivity performance may be poor during their first years in the market.

The entrants' contribution in the Japanese manufacturing sector's productivity growth is the highest when we consider the TFP-m as the productivity measure of the analysis. Besides the aggregate total factor productivity growth is rather low (the 5-yearly growth is around 3%, and the 10-yearly growth is around 5% according to both TFP and TFP-m) relative to the labor productivity growth, the calculated entry contributions with TFP-m is much higher than those based on other indices. It is worth nothing that the value of the entry component is approximately same among alternative formulations and time spans indicating that TFP-m does not underestimate the role of entrants in the industry dynamics even for shorter time intervals.

The overall picture depicted for Korean manufacturing industries are not very different from the Japanese case, so that the entrant plants' contribution to the productivity growth is highest when we consider the TFP-m as the productivity measure. The net entry contribution to the labor productivity growth is negative according to the BE and revised BE methods, while the original entry component of the FHK method indicates a positive contribution in both 5 and 10-year intervals. The entrants' role in the labor productivity dynamics significantly differ in alternative decomposition formulations highlighting the importance of extracting the aggregate growth effect from the original entry component of the FHK decomposition. Moreover, the respective net entry contributions of the BE and revised BE methods also vary in the decomposition TFP-m for Korean manufacturing sector mainly due to the significantly different productivity dynamics observed for the entrants and incumbents. Therefore, since the incumbents are experiencing negative and very low productivity growth rates in Korea, the aggregate growth effect in the FHK's entry contribution is relatively low when we consider only the incumbent firms in the calculation of the aggregate growth components as it is offered by the revised BE methodology.

7 Conclusion

The analysis of firm level productivity dynamics is an important branch of the empirical research on understanding how producers process inputs to turn them into output. Besides providing insights into the cross-country differences in the firm behavior, the economics of productivity significantly contributes to the knowledge of economic growth and micro-economic restructuring that is ongoing in an economy or industry. However, although the theoretical concept of productivity is rather well established, its measurement in practice is still ambiguous, especially if the quantities of inputs and outputs are not directly observable.

Early literature on firms' productivity performances rather neglected the problem of unobserved quantities and prices by defining the output as the firm revenue that is price-adjusted by aggregate level deflators. However, recent availability of detailed micro-level datasets reveal the fact that what we observed as productivity so far, actually involves the external factors that are generated regardless of the technical efficiency in the production process. These factors can be in the form of adverse shocks from demand or input suppliers' sides and enters into the productivity measurement through the unobserved idiosyncratic price-cost markup variations. As it is empirically supported, these unobserved price effects may highly distort the quality of the productivity index when the markup variation among firms has a systematic pattern. In particular, newly created production units face asymmetric shocks arisen especially from the demand side, which prevent entrants to be as profitable as incumbents by charging high enough prices during the start-up phase.

In this paper, we provide empirical support on this fact that the entrants set on average lower markups than those of the incumbents in Korean and Japanese manufacturing industries. Assuming the plants are price takers in the input market, our findings can be interpreted as a sole result of the idiosyncratic demand shocks. However, we do not restrict ourselves to a specific market condition or a production relation, so that the adverse shocks faced by the producers may well be originated from the input suppliers' side that may increase the input prices of the entrant plants in an asymmetric way.

In addition to the insights regarding the heterogeneity in the plants' pricing behavior, our approach provides a productivity index that is adjusted according to the markup variation of the entrants and the overall industry markups that are not equal to one. While doing so, we also take into account the factor elasticity variation within the industries, in particular, the returns to scale variation of entrants from the industry average. Moreover, the proposed estimation methodology further controls for the possible correlation between the two unobserved components, markups and productivity, as well as the endogeneity of input usage to production by introducing a control function approach where all the production function parameters are identified in the last sage of the estimation routine. Therefore, the last section of our study compares the firm level productivity dynamics observed through the traditional measures of productivity and the index retrieved from the proposed method.

Accordingly, we conclude that the average productivity growth rates of the entrant plants in their first four years are lower than the incumbents in both Japanese and Korean manufacturing sectors when we consider the standard labor and total factor productivity measures. However, the total factor productivity index retrieved by controlling for the markup variation of the entrants indicates that the entrant plants' productivity growth rates are significantly higher than those of the incumbents. Secondly, by using alternative productivity growth decomposition frameworks, we calculate the productivity contribution of the entrants for longer time intervals that are 5 and 10 years respectively. Our results further demonstrate that the entrants' contribution to the productivity growth is significantly higher, when we account for the markup variation of the entrants in the estimation of the productivity.

Our findings highlight the importance of the distortionary price effects in the measurement of the productivity at the micro level. This is especially crucial if the variation of the demand side factors involved in the productivity indices has a non-random pattern. Thus a particular group of producers' production performance would be evaluated inaccurately, if we ignore their variation from the industry average. In this paper, we only consider the entrants as the group of plants that deviates from the overall industry dynamics, but one can rely on alternative classifications such as domestic and foreign, public and state-owned firms for which the pricing behaviors possibly differ even within narrowly defined industries. Since it is not feasible to account for all possible systematic micro-level deviations within a single production function estimation routine, firm level productivity analysis vitally needs more elaborate data where the prices or quantities are separately observed at the most disaggregated level. In this respect, the concerning implications of the early literature further need to be re-tested in all aspects.

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Appendix

Construction of Variables and Detecting the Outliers

Besides the input and output variables discussed in the main text, the estimation procedure further requires to obtain the respective factor expenditure shares in the total revenues. However, in the original dataset, only the total hours worked as labor input, the price adjusted capital, the material expenditures and the revenues are reported together with the each input's expenditure share in the total input expenditures for every plant and time period. Moreover, as it is explained in Fukao et al. (2009), the expenditures on material inputs and the revenues are deflated with the same price index (2-digit industry level PPI) that enables us to retrieve the input expenditure to revenue ratio for the labor input conveniently in the following way.

The material expenditure to revenue ratio is calculated by the ratio of the deflated material expenditures to deflated revenues ratio, since both variables are adjusted by the same price index. Moreover, since we have a variable that represents each inputs' expenditure share in the total input expenditures, that is z_{it}^J where $J \in \{M,\ L\}$, than the total expenditure on labor to revenues ratio can be written by the following formula that is irrespective of the value of the total costs.

$$\frac{w_{it}L_{it}}{p_{it}Q_{it}} = \frac{c_{it}M_{it}}{p_{it}Q_{it}}\frac{z_{it}^L}{z_{it}^M} \tag{A.1}$$

In the above formula, p_{it} is the output (Q_{it}) prices, w_{it} and c_{it} are the input prices for labor (L_{it}) and materials (M_{it}) respectively. It is worth mentioning that in the dataset, the capital's cost share in the total input expenditures is also reported, where the capital's user cost is calculated through an approximation over the variables such as the interest and depreciation rates, the capital price deflators that results in a same capital input price value for all the plants in the 2-digit industry. Therefore, besides it is technically possible to retrieve a capital cost expenditure to revenue ratio for each plant and time period by this variable, we already assumed in the main text that the user cost of capital is not observable due to the possible errors in its approximation, so that we do not need its respective share in the proposed analysis.

Moreover, when detecting the extreme values, we first estimate the production functions through the proposed algorithm by using the full sample. Then we re-center the retrieved TFP index of the full sample by extracting the mean of each 2-digit industry and time period from the plant-level TFP in logarithms. In the next step, we rank the firms according to their re-centered productivity draws and for the group of entrants and incumbents separately for each time period. Lastly, within each group, we detect the firm-time observations that are 4.2 standard error far away from the mean as the outliers. This process leads the deletion of approximately between 1% and 2% of the total number of firm-time observations for each country. In the Korean first differenced dataset we have 13139 firm*time observations, and in the Japanese first differenced dataset there are totally 28995 firm*time observations.

App. Table 1: Summary Statistics (in 2000's prices)

Levels		Output Jap. yen	Labor man-hours	Materials Jap. yen	Capital Jap. yen
Japan					
	Mean	108802621	3668371	88415033	45356663
	Std	360405257	9797515	304745977	155806339
Korea					
	Mean	11310196	2309099	32710523	11310196
	Std	76825891	8108075	236974182	76825891
Growth Rates					
Japan					
	Mean	0.019	-0.022	0.017	0.024
	Std	0.141	0.108	0.144	0.151
Korea					
	Mean	0.119	0.014	0.127	0.173
	Std	0.337	0.262	0.345	0.642

App. Table 2: Entry and Exit Rates (%) in Japanese Industries

Code	Entry R.	Exit R.	C.V. Labor	C.V. Materials	#Firms
6	1.61	0.37	1.65	2.17	138
7	0.01	0.08	1.27	1.29	27
8	1.08	0.42	1.34	1.31	43
9	2.20	1.00	0.93	1.11	9
10	1.67	0.49	0.92	0.96	11
11	0.47	2.62	1.27	1.47	34
12	1.69	0.11	1.99	2.54	26
13	0.58	0.87	1.41	1.70	202
14	0.14	1.35	0.91	1.31	10
15	8.28	0	0.63	0.72	3
16	0.73	1.02	1.50	1.98	79
17	0.50	0.77	2.29	2.14	104
18	2.01	1.09	1.48	1.78	88
19	0.57	0.60	2.41	2.92	231
20	0.64	0.34	2.96	3.51	232
21	0.60	0.25	2.08	3.08	107
22	0.46	0.85	0.97	1.51	29
23	1.06	0.48	1.13	1.40	48
24	1.15	0.23	1.62	1.72	62

The entry and exit rates are the annual averages and based on the plants' labor shares.
"C.V." represents the coefficient of variation.
"#Firms" stands for the average number of firms in the industry.
"Code" is the respective 2-digit industry codes.

App. Table 3: Entry and Exit Rates (%) in Korean Industries					
Code	Entry R.	Exit R.	C.V. Labor	C.V. Materials	#Firms
6	0.71	0.00	1.23	1.46	48
7	0.10	0.01	1.10	1.12	23
8	0.68	0.17	1.03	1.85	25
9	0.10	0	0.57	0.29	4
10	0.52	0	1.12	0.87	7
11	0.33	0	1.08	1.43	30
12	6.04	0.56	1.29	1.78	29
13	1.22	0.02	1.91	2.68	116
14	0.11	0	1.45	1.89	4
15	0.55	0	1.08	0.53	5
16	0.07	0	1.11	1.61	28
17	0.21	0.07	3.18	3.44	63
18	0.99	0	2.49	3.43	28
19	2.00	0.10	1.48	2.70	52
20	1.87	0.06	4.64	5.33	163
21	0.44	0	3.39	3.57	51
22	1.04	0	1.34	1.43	6
23	1.04	0.05	2.62	3.26	19
24	1.71	0	1.50	2.02	20

The entry and exit rates are the annual averages and based on the plants' labor shares.
"C.V." represents the coefficient of variation.
"#Firms" stands for the average number of firms in the industry.
"Code" is the respective 2-digit industry codes.

App. Table 4: The Manufacturing Industries Used in the Analysis

Industry Code	Definition of the Manufacturing Industry
6	Food and kindred products
7	Textile mill products
8	Apparel
9	Lumber and wood
10	Furniture and fixtures
11	Paper and allied
12	Printing publishing and allied
13	Chemicals
14	Petroleum and coal products
15	Leather
16	Stone clay glass
17	Primary metal
18	Fabricated metal
19	Machinery non-electrical
20	Electrical machinery
21	Motor Vehicles
22	Transportation equipment and ordnance
23	Instruments
24	Rubber and misc plastics

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